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Working paper N. 5/1995

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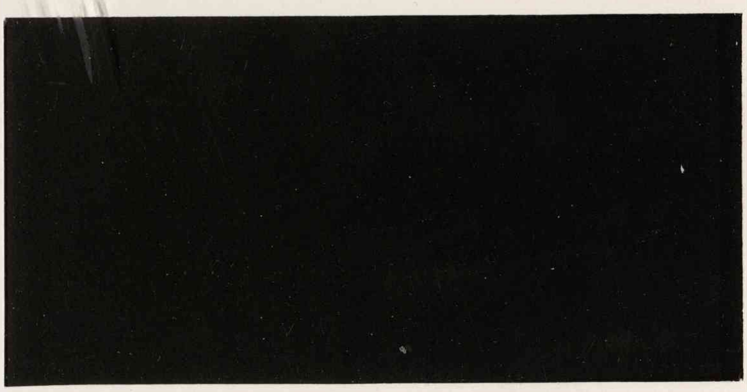

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REGULATION AND TOTAL PRODUCTIVITY PERFORMANCE IN ELECTRICITY: A COMPARISON BETWEEN ITALY, GERMANY AND FRANCE

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Abstract

Notwithstanding EC's invitations to promote competition in the electricity industry, only the UK seems to have evolved towards a real liberalization, while the other countries have introduced few innovations. Italy and France are organized as integrated monopolies, whereas Germany still remains a collection of mixed owned or public owned "de facto" regional monopolies. Each country is characterized by different regulatory systems aimed at controlling tariffs, productivity and quality. In this study we have evaluated the performance of three large electricity companies: EdF, ENEL and RWE, in order to estimate how regulation contexts and regulatory interventions could have influenced their results. EdF shows the best performance characterized by a rising trend during the eighties, whereas Enel enjoyed good results in the seventies followed by a stagnation period until 1987; after a negative trend until 1989, RWE seems to have shown some signs of recovery in recent years. The empirical findings are consistent with theoretical suggestions about the weaknesses of rate of return regulation and the impact of quality constraints regarding the factors.

Keywords: electricity, total factor productivity, regulation.
JEL classification: L33, L51, L94.

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1. Introduction

Economic performances of firms are attributable to managerial skills as well as to external factors, such as government interventions, market trends, evolution of prices of raw materials, and so on.

The influence of external factors might be very important in regulated industries. In particular, in the electricity industry, policies such as control of prices, subsidization, fiscal facilitations, play an important role in explaining the performance of firms.

Focusing on regulated industries, it is possible to find out some common characteristics affecting the supply and the demand of goods or services. On the supply side, the possible presence of significant economies of scale implies that average costs decline with firms' dimensions. Another common feature is the considerable level of capital intensity, as in most regulated industries fixed costs such as plants and equipment are very high. Moreover, as they have been characterized by considerable technical changes, utilities have had good opportunities to increase efficiency (Cowing and Stevenson, 1981). On the demand side, regulated industries have attracted an increasing demand over the years. From the above discussion, it seems that there are large potentialities for obtaining efficient results, especially for monopolistic firms. In reality, interventions such as price policies, cross-subsidization of tariffs and favours accorded to some critical industries have a considerable influence on mitigating the weight of the potentially favourable profit conditions.

European bodies have recently focused on the electricity industry, for the purpose of constructing a Single European Market for energy. This aim should be obtained through free exchanges between the member States and competition between firms in a common regulated environment. The behaviours of European countries in the face of EC's bodies proposals are very heterogeneous and vary from the introduction of a real competitive market (England and Wales) to the maintenance of a totally integrated system (France). Even if this situation is changing and going towards more competition at present we may find many monopoly structures that probably will still be operating for a long time. Moreover we must not forget that electricity distribution will maintain its conditions of natural monopoly at least in sub-national areas. For these reasons it becomes important to identify the economic goals of regulation and to assess the performance of firms operating in different monopoly conditions.

In this study we will compare the performances obtained by three firms: ENEL, EdF and RWE. The former two are structured as national State-owned monopolies, while the latter is a mixed-owned firm which controls about 26% of the German electricity generation.

The theoretical background about regulated monopolies is reviewed in section 2. Section 3 deals with the main characteristics of Italian, French and German electric power industries, while section 4 concentrates on the regulatory mechanisms operating in each country. In section 5 the methodology that has been adopted to measure productivity is presented and discussed. Section 6 contains the main results and section 7 summarizes.

2. Monopoly regulation and incentives

2.1. Economic goals of monopoly regulation

Regulation in natural monopoly markets is mainly aimed at maximizing the sum of consumer and producer surplus. This goal can be achieved by improving general cost efficiency within the firm's existing technology as well as by introducing innovation through new technologies. This means that regulatory constraints should induce firms to minimize their production costs (while remaining at the same time economically viable), to produce outputs at economically efficient levels, to innovate and to pursue diversification strategies only where they are economically efficient (this implies that regulatory bodies should avoid deterring welfare maximizing diversification). In our opinion the incentives towards those directions could be very important to explain the performance of regulated electricity firms.

The theoretical literature dealing with the effects resulting from different regulatory systems is mainly concerned with the property-rights, the different resource allocation resulting from alternative pricing schemes and the constraints about the quality of the service.

2.2 Property rights and economic efficiency

An important distinction between private and public enterprises relates to the transferability of property rights and the connected consequences concerning cost-minimizing conducts (Crain and Zardkoohi, 1978). This theory suggests that, as it is very difficult (if not impossible) for owners of a public firm to transfer their shares, the interest for the net present value of the firm's future performances is reduced. On the contrary, the possibility to exchange ownership shares of a private firm creates good opportunities for capital gains which could be exploited by owners who are able to find enterprises endowed with more efficient procedures. As a consequence of this situation public enterprise managers are less motivated than their private counterparts to pay attention to future cash flows and therefore their opportunity cost of inefficiency is reduced. Moreover, the reduced interest for the capitalization of current decisions involves short-run perspectives for strategic decisions.

Some other arguments are linked to the political pressure aimed at obtaining votes which charges public firms with labour intensive processes.

There is empirical evidence that private performances are better than those obtained by public owned firms but, particularly for utilities such as electricity, gas and water, a counter-argument could state that regulation systems could be able to get over the implications of property rights. Meyer (1975), studying a sample of electric power generation firms in the United States, provided the evidence of costs differences over public versus private ownerships. The comparison indicates significantly higher costs for privately owned firms that seem to be associated with a regulated environment. In particular, the results appear to be consistent with the Averch-Johnson (1962) hypothesis about rate of return regulation which will be discussed in the next section.

2.3 Resource allocation and pricing schemes

The debate concerning the electricity system focuses on economic efficiency as a primary pricing target. The guidelines necessary to implement an efficient price system could be linked to three primary objectives: a fair financial return on capital, a fair distribution of the firm's allowed revenue among the beneficiaries of the service and a rate structure able to discourage the waste of public service (Bonbright, 1961). Putting aside the rate design we will focus our attention on the capability of price regulation to improve productivity by correcting costs and prices. Even if from a theoretical point of view some effects are straightforward, on the empirical ground it is difficult to prove rigorously how regulatory interventions might have induced firms to minimize costs or to set correct price levels (Wenders, 1989).

From the empirical point of view there are two ways of regulation which could be associated on the one hand to social contracts or price caps and on the other hand to rate of return schemes.

The literature about rate of return regulation underlines some positive effects. Its primary goal is to come close to the theoretical results of competition, where costs and revenues equate each other. The risks of costs increases and the benefits of costs reductions are to be assigned to consumers; in such an environment it could be easier for firms to produce quality and to undertake some innovative investments characterized by uncertain returns.

On the other hand many research projects starting from the work of Averch and Johnson (1962) have stressed some inefficiencies created by rate of return regulation. This literature emphasizes that a regulatory system based on this kind of constraints can generate a process of misallocation of resources.

The "A-J effect" suggests that if the allowed rate of return exceeds the correct remuneration of capital firms will accept a capital labour ratio which does not allow a correct minimization of costs. Moreover, a diversified firm operating both in a competitive and in a monopoly market, under profit level regulation on the combined markets might have a long run incentive to price below long run marginal cost in the competitive market and to raise its prices in the monopoly market. This means that potential entrants might find it more difficult to enter the competitive market (Doyle, 1994). Regulation could relate only to the monopoly market but problems might occur about information costs. It is difficult to distinguish the portion of common costs to be assigned to monopoly services from that relative to competitive services because of the firm's interest in increasing the portion of costs to allocate to the monopoly business (Hillman and Braeutigam, 1989). Moreover, because of the presence of information asymmetries, rate of return regulation proves to be very expensive (Leite et al., 1994).

Price cap regulation, which is based on direct price constraints, could be a better way to replace the indirect rate of return regulation.

Under price level regulation the effective unlinking of the firm's allowed revenues from its internal costs could create the interest to produce the required output at minimum cost. Furthermore, price-caps imply that firms have prospective behaviours as they are not determined by historical costs. It is possible to point out some drawbacks of price level regulation. First, as the risks of cost increases are to be borne by the firm, the latter might be reluctant towards new innovative investments. Second, it becomes more difficult for firms to support unprofitable but socially desirable output expansions directed at getting a complete service coverage. Social contracts are based on the same concept of price caps and can be considered as a variant having the same strong points and weaknesses.

2.4 Quality constraints

The provision of quality by a regulated monopoly is modelled by Laffont and Tirole (1993). They examine the condition of "search goods" (where quality is observed before purchasing) and the condition of "experience goods", (where quality is observed after purchasing): electricity falls into this latter case. They argue about the conflict between the incentive to supply quality and the opposite goal of cost reduction; the "cost-reimbursement rule" might contemporaneously lead to the achievement of both of the two objectives. Anyhow it must be noted that the difficulties of measuring the quality costs weaken the effectiveness of the regulatory system. Put in other words, "the more important quality is, the lower will be the power of the optimal incentive scheme".

Turning to electricity systems, the implications of quality provisions could be enlarged to the constraints about the nature of the productive factors and of the rate policy. When firms are obliged to use a particular kind of coal or a particular technology, to supply areas with high distribution costs or to accept bureaucratic processes for the localization of new plants that take a long time to be carried out, it becomes difficult to control productivity. In short, if we decide on price cap, we will probably reduce the incentive to provide quality. On the other hand, if we prefer a rate of return system, we will have fewer possibilities to obtain productivity improvements.

3. Electricity industries in Italy, France and Germany

In 1962 most of the existing Italian electric power companies were nationalized and grouped in a single State-owned company, named ENEL. From that date on ENEL has been responsible for more than 80% of electricity production and for more than 87% of total distribution, the rest being controlled by some already existing municipal firms (4% and 12% respectively), by some self generators having a share of self production higher than 70% and by small firms with a yearly production-lower than 15 Gwh.

In 1982 private firms were allowed by law to produce electricity, but the bureaucratic restrictions and the low price of resale of surpluses to ENEL rendered this reform almost ineffective (Fraquelli and Ragazzi, 1994). More promisingly, in 1991 production by private companies was favoured, especially for energy produced by renewable sources and through co-generation, and exchanges between subsidiaries of the same group were allowed. Their prices of resale of surpluses to ENEL were also made favourable. This represented the first decisive step towards the creation of a more competitive industry. In 1992 ENEL was transformed into a joint stock company; this was done in the perspective of a future privatization that is still being discussed.

In France too there is a monopoly with EdF producing 92% and distributing 96% of the total generated electricity. In fact the law that introduced nationalization in 1946 saved only some small existing power generators, some self producers, and few municipal or State-owned distribution firms.

The policy carried out by the French government was aimed at increasing the weight of the electric power industry, with a sequence of massive investments that led EdF to become a structural exporter from 1982 on. Recently, following EEC bodies' interventions about competition and liberalization, a debate took place in France and the dismantling of the

monopoly in electric power production was discussed, while the maintaining of the distribution monopoly was restated (Mandil, 1994).

The electricity industry in the Federal Republic of Germany is divided into three sectors: public supply, industrial supply and supply to the federal railway system. The first market absorbs more than 86% of the total and includes all supplies of electric power to third parties. Nine big firms control almost all the production and the national distribution of high-voltage electricity; there are then about 40 regional distributors and 1000 local suppliers. It has been estimated that RWE controls about 26% of the total generated electricity in Germany.

The system is structured as a collection of regional and local monopolies, since exclusive dealing and exclusive territories are allowed by concessions. Cooperation between potentially competitive firms is not challenged by the federal antitrust law. This policy has the purpose of granting a sure and continuous supply but it involves a low level of competition.

As to ownership, we could distinguish between private ownership, mixed ownership and public authorities ownership, with the first one absorbing less than 20% of the total generation and less than 10% of the total distribution of electric power.

4. EC rules and regulation in Italy, France and Germany

4.1 EC rules

In 1988 the EC Commission introduced some rules and principles for the purpose of creating an integrated European market for electricity. These guidelines concerned mainly the safety of supply and the promotion of competitiveness: goals that should have been reached through free exchanges between the member states.

In 1989 all this was made more precise by specifying:
- right of transit on the big electricity grids;
- right of access of third parties to the electricity networks;
- transparency of tariffs;
- transparency of costs;

These proposals concretely concern a separate accountancy for generation, transmission and distribution (unbundling), the abolition of monopolies with regard to exports and imports, the increasing attention paid to environmental protection and the abolition of cross-subsidization between categories of consumers.

As far as the degree of compliance with EC rules is concerned, it seems that only the UK has implemented a radical reform of its electricity industry. In fact, in 1990 the UK government, following a privatisation and liberalisation strategy, led to the separation of the industry into four areas of activity: generation, transmission, distribution and final supply. Production is almost completely controlled by two private firms and a state-owned firm, transmission is entrusted to a single company, which is owned by the twelve regional distribution firms. The latter are obliged to put their network facilities at the disposal of third parties willing to use them and have been allowed to produce up to 25% of the electric power they distribute. Finally, the commercial activity can be accomplished by the regional distributors, by some other intermediate firms or by the producers themselves.

4.2 *Regulation*

4.2.1 *Italy*

In 1993 all Italian regulatory organisms were concentrated in CIPE, while in 1994 prices were put under the direct control of the Ministry of Industry. Since ENEL is a public monopoly, there has not been the need to implement a formal regulatory authority responsible for the supervision of the electricity industry. This does not mean that Italy has not been affected by regulatory decisions; in fact it is possible to identify at least two important interventions in the energy industry in Italy.
The first one is the Programming Contract of 1991 which foresees that variations in the level of tariffs should be linked to variations in the costs of production, but tariff increases should be reduced by an improvement of productivity by 1.5% per year.
The second, a kind of behavioural code, was introduced by law in 1994 and refers to the public services supplies. Its main task is to improve quality in the service and to promote efficiency in the management of public utilities.
Regarding legislation, some interesting laws must be emphasized:

- the law of 1982, made to favour private power generators, still contained important drawbacks for new firms willing to enter the electricity market. It has already been said that in this respect the law of 1991 has been more effective;
- in 1992 ENEL was transformed into a joint stock company; this change together with the aim to privatize involved the need to study a concessionary scheme that was transformed into law in September 1995 with the institution of the authority for the energy industry.

Finally, we must not forget that the referendum of 1987 led to the prohibition of the further use of nuclear sources to produce energy, at least until 1993[1].

4.2.2 *France*

The French system is based on a law dated 1946. EdF is controlled directly by the Ministry of Economy and Finance and by the Ministry of Industry. There is no regulation authority, but some important contracts between EdF and the Government have been made:

- the Programming Contract 1970-1975 regarded investments and a tariff regulation scheme based on the nominal inflation rate;
- the First Planning Contract 1984-1988 was concerned with reducing the level of tariffs by paying attention to real price evolutions (Gabet, 1986);
- the Second Planning Contract 1989-1992 was aimed at reducing electricity tariffs and at finding a solution for the worrying level of debt reached by EdF during the eighties. It is worth noticing that in 1989 EdF signed an important contract with GdF (which monopolizes the production and the distribution of gas in France) for the purpose of generating significant economies of scale through the harmonization of their respective Distribution Departments.

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[1] It is highly unlikely that a changing trend will occur in the near future.

4.2.3. Germany

The German electricity industry is based on a law of 1935. In Germany there are some different regulatory bodies:

- at municipal level the councils grant exclusive concessions lasting 25 or 50 years and levy some taxes on electricity (about 20% of the firms' incomes). The amounts relative to the concession rights are generally high too;
- at state level there is the supervision of actions that have been undertaken by the municipalities; the control is aimed at avoiding the presence and the development of small inefficient firms;
- at the federal level the law of 1935 encourages cooperation between firms, grants exclusive territories and exempts the electricity industry from respecting antitrust rules.

As for regulation interventions we can distinguish between structural regulation and behavioural regulation. The former is relative to the concession of licences and authorizations, as well as to the control of entries and exits, while the latter concerns the control of prices and profits:

- *investments, exit and entry*: while investments in coal fired power plants are favoured, those in gas or oil based power plants are discouraged; in addition, the environmentalists have put a serious obstacle to the development of the nuclear energy. As to entries, new concessions are denied if the region in question is already served, while firms that exit the market are preferably replaced by firms operating in the neighbouring regions (Muller and Stahl, 1995). The government's protection policy to the advantage of the coal industry finds further confirmation in the favour granted to the two long-term contracts, signed between the state-owned coal mines and the electricity suppliers (Oberlack, 1986).
- *right of way across municipal property*; this is granted by exclusive concessions of distribution of electricity lasting 25 or 50 years;
- *dominant power abuse*; the federal antitrust authority intervenes in situations where prices vary greatly between neighbouring exclusive territories and, more in general, when a deviation from the behaviour that would be expected in a competitive environment is discovered.

In 1990 the reform of the antitrust law involved the introduction of some new competitive mechanisms, by stating that all new concessions should be accorded for a period lower than 20 years, and that existing concessions older than 20 years should terminate in 1994.

Regarding price regulation, Germany seems to be continuing rate of return regulation, whereas France, and to a lesser extent Italy have paid more attention to the containing of costs, and have made use of social contracts as high- powered means of regulation.

Table 1 summarizes some interventions directed at controlling the electricity industries in countries examined in this study (laws, programming contracts, private contracts approved or promoted by the governments, etc.) as well as the effects that would be expected in the performance of firms.

5. Measuring productivity

5.1 Total factor indices

The main economic activity of a firm consists in transforming a set of inputs into one or more outputs. There are different methods that might be used to obtain the same output; for example, in the electricity industry different sources can be used for fuel in order to produce electric power: table 2 shows the different set of materials that have been used by ENEL, EdF, and RWE. Similarly, inputs can be aggregated in several ways: table 3 highlights each input's relative share in our three firms. The nature and the magnitude of each input depend on several factors, such as the home country's economic situation, the relative price of each input, the particular business links between firms (such as contractual relationships with firms operating in downstream industries and in upstream industries or vertical integration links between subsidiaries of the same group), and the different legislation in force in each country. Regulation may be considered as part of this latter factor and influences economic decisions of firms.

Given a set of inputs a more efficient technology results in a greater quantity of output. As different inputs have different costs this problem turns into that of cost minimization. Then one firm is considered more efficient than other firms when it is able to obtain the same output by using a cheaper set of inputs.

Two problems arise at this point. The first one is relative to the degree of homogeneity between outputs: electricity is not the only output produced by electric power companies; for example quality is expensive and should be valued. Quality is particularly important as the electricity supply is essential for industries and for households. The frequency of technical faults and energy losses, the length of connecting times, the efficiency and the timeliness of repairs and maintenance work should be taken into consideration for a correct analysis of efficiency. In the same context we could include the level of pollution produced by electric power firms, with the consequent need to make investments in order to reduce the harmful emissions of SO_2 and NO_x and to move towards the use of cleaner sets of power sources.

The second problem is relative to the effects of inflation. As inflation rates affect the values of costs and sales erroneous increases in efficiency might result from analysis based on current values. A correct analysis should consider constant prices by assuming a base-year for prices, so as to concentrate the attention on the changes of the mix of physical inputs[2].

In our analysis we will make use of two total factor productivity measures. The first one is represented by a quantity index which puts into relation outputs and inputs at base-year prices. The productivity ratio between two subsequent years is:

$$TFP_{B\,t,t-1} = \frac{\sum_{i=1}^{n} Y_i^{t} \cdot p_i^{to} / \sum_{i=1}^{n} Y_i^{t-1} \cdot p_i^{to}}{\sum_{h=1}^{g} X_h^{t} \cdot w_h^{to} / \sum_{h=1}^{g} X_h^{t-1} \cdot w_h^{to}}$$

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[2] The base year is 1989 for EdF, and 1993 for ENEL and RWE. We have then multiplied physical quantities of inputs and outputs by their base-year prices. The only exception relates to the depreciation rates employed for ENEL; we used 1983 as the base-year to obtain constant depreciation rates for the different categories of assets.

where i indicates the different goods, h indicates the different inputs and to is the base year. As inputs are simply added up, it implies perfect substitutability.
The second measure is the Törnqvist index, an approximation in the discrete case of the Divisia indices. The latter are derived from Solow's production function, which implies constant returns of scale and neutral technological change (Diewert, 1981). In the situation of one output and two inputs (labour and capital) it takes on the following expression:

$Y(t) = A(t) \cdot f[\, L(t), K(t) \,]$, where $A(t)$ is the technological progress; the relative variation of the technological progress over time is:

$$\frac{dA(t)}{A(t)} = \frac{dY(t)}{Y(t)} - \left[a(t) \cdot \frac{dL(t)}{L(t)} \quad b(t) \cdot \frac{dK(t)}{K(t)} \right]$$

with a indicating the relative weight of labour and b indicating the relative weight of capital.

Putting $dA(t)/A(t) = \dot{A}(t)/A(t)$ equal to the variation of productivity over time $(\dot{TFP}_D(t)/TFP_D(t))$ and considering the n-goods and g-inputs (X) case we have:

$$\frac{\dot{TFP}_D(t)}{TFP_D(t)} = \sum_{i=1}^{n} \Theta_i(t) \cdot \frac{\dot{Y}_i(t)}{Y_i(t)} - \sum_{h=1}^{g} \Phi_h(t) \cdot \frac{\dot{X}_h(t)}{X_h(t)}$$

The Törnqvist approximation of the above index[3] takes on the following form:

$$TFP_{T\,t,t-1} = \frac{\prod_{i=1}^{n} (Y_{i,t}/Y_{i,t-1})^{1/2(\Theta i,t + \Theta i,t-1)}}{\prod_{h=1}^{g} (X_{h,t}/X_{h,t-1})^{1/2(\Phi h,t + \Phi h,t-1)}}$$

The numerator and the denominator can be considered as geometric means of the quantity ratios with weights being represented by the average expenditure shares for factors and by the average sales shares for goods (Morrison, 1993). As the first indices are used with fixed-base prices and Törnqvist indices with variable-base prices, the latter take into account relative price changes; this means that they are sensitive to strategies that reduce the weight of such inputs that have become more expensive.

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[3] The same index has been adopted by Solimene (1994) in her study of the productivity growth in the Italian telecommunication industry.

5.2 *Inputs and outputs*

For ENEL we derive six categories of users (households, public lighting, other customers purchasing up to 30 Kwh, from 30 to 500 Kwh and more than 500 Kwh, resellers); for France we consider high-voltage, medium-voltage and low-voltage sales; for RWE we separate direct deliveries (special contracts for supplies to industries and public lighting, contracts with customers at tariff rates) and indirect deliveries (deliveries to electricity companies and exports).

Labour is measured by the average number of employees for each year, while purchases of electricity are expressed in Kwh.

As to the estimation of the cost of capital, we moved away from the simple consideration of financial charges; since a correct measure of the total cost of capital should include the opportunity cost of equity, firstly we have derived an estimation of the total capital invested in the firm (by subtracting from net assets (at CPP prices) the amount relative to commercial debt and other current liabilities), secondly we have applied to that value a real rate of interest of 4.4%[4].

The level of depreciation has been obtained by employing two estimates; the first one is a simple revaluation of the book value as it is recorded in the profit and loss accounts. We believe that this value does not represent a good indicator of physical depreciation and economic obsolescence of installations and machinery, as fiscal reasons and inflation rates have an high influence on it and may lead to biased values that are not economically acceptable. The second estimate, which results from the application of the perpetual inventory method, enables the obtaining of a "real value" of assets for each year. Average depreciation rates drawn from annual reports have then been applied to the gross values of fixed assets. This method takes account of the fact that for each year the value of fixed assets is the result of a stratification process, with investments and disinvestments respectively increasing and decreasing the amount recorded at the beginning of the year.

Starting from a base year (1963 for Enel, 1971 for EdF and 1980 for RWE) additions and withdrawals have been added at constant prices following the equation below:

$$K_{t+n} = K_{t+n-1} + I_{t+n}/IP_{t+n} - D_{t+n}/IP_{t+n-z}$$

where K_{t+n} indicates the value of fixed assets for year t+n at the prices of year t and IP_{t+n} is the price index for year t+n. The use of the price index of year t+n-z for deflating withdrawals points out the fact that in general disinvestments are not relative to machinery purchased or constructed during the current year but instead they reflect withdrawals and sales of old equipment.

In our examined cases this process has led to very high values of gross fixed assets, as compared to the book values recorded in the balance-sheets; this reflects the fact that accounting systems based on historical costs do not take into account the effects of inflation.

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[4] This value represents the average real cost of long term Bonds and equity in Italy.

6. The results

6.1 Structural differences between the firms

Before going on with the illustration and the discussion of our main results it is necessary to stress some remarkable differences between our three firms. While EdF and ENEL are two state-owned monopolistic firms, RWE Energie is a formally mixed owned firm operating in a more competitive environment (see section 2). EdF and ENEL are integrated forward in the transmission and distribution stages, but they are not integrated backward in the supply of fuel. On the other hand RWE Energie is part of a group which has a complete control over a subsidiary that mines lignite which is highly used to generate electricity. The importance of RWE's interests out of the electricity industry has increased in time. In fact Energy absorbed 60% of the total sales of the group in 1980, and just 35% in 1993[5].
Finally, productivity increases can be reached through a more efficient combination of inputs, but they are also due to the driving force of demand growth.

6.2 Partial productivity results

Regarding labour we can observe from table 4a that ENEL and EdF have achieved good productivity results. From 1980 to 1993 they obtained almost the same improvement with an yearly average growth rate respectively of 4% and 3.7%. The case of RWE is quite different, with a productivity level of workers remaining almost constant during the period. EdF's positive results are especially due to the production expansion strategy, while for Enel we can see a good labour saving policy.
It is worth noticing that the high level of absolute efficiency indicated by the number of customers per employee (table 5) offers a confirmation of the positive results reached by ENEL and EdF.
As for total consumption, if we sum up the amounts of purchases and fuel consumption (table 4b), we can notice that only Edf has been able to contain its costs: the decreasing trend during the seventies was reversed during the eighties but only in 1986 was EdF able to achieve the same levels recorded in 1971. The performance is clearly linked to the nuclear program which in the last few years allowed EdF to double its partial productivity levels[6].
Physical capital productivity performances can be analysed by paying attention to the book values or, alternatively, through the application of the perpetual inventory method. If we consider the depreciation as it is booked in the profit and loss accounts, we find a picture in which only ENEL seems to have had a negative performance. This is due to the fact that in Italy, after a very difficult period (lasting until 1982-83) with insufficient rates and

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[5] The other main branches of activity are mining (4%), oil and chemicals (40%), mechanical and plant engineering (11%).

[6] These results do not include completely all the costs that EdF will bear in the future to manage its nuclear power plants after their dismantling. In fact, the provisions for the management of nuclear sources booked in the balance sheets are estimates which could not correspond to the effective costs.

consequently very low provisions, nominal depreciation rates have been increased to recover inflation. For such reasons we do not believe that this information represents a correct measure of the depreciation of assets. The values obtained through the application of the perpetual inventory method display a negative performance for all our three companies. We can analyse this result by stressing that RWE, like many other German electric power firms, has made large investments for the purpose of containing the level of pollution produced by coal fired plants; on the other hand ENEL's problems concerning the finding of sites for new plants together with the environmental costs and the interruption of nuclear plans have played an important role[7].

The performance of the cost of financial capital suggests that ENEL has been more successful in balancing external and internal sources, while EdF was characterized by financial problems in the mid eighties. On the other hand RWE has shown a negative trend.

Table 4c and 4d consider the total cost of capital in its physical and financial aspects. If we compare ENEL and EdF they seem to have the same positive performance but we cannot forget that nuclear technology leads to a saving in fuel consumption and purchases of electricity.

6.3 Total factor productivity

The above discussion of partial performances offers a picture in which EdF holds a position of primary importance: this finds further confirmation in the levels of total factor productivity indices. As can be observed in Figure 1 (TFP_B indices), EdF was characterized by a rising trend during the eighties while ENEL, after having enjoyed good results in the seventies, entered a stagnation period that ended around 1987. For RWE, some signs of recovery can be seen in the last few years following a negative trend lasting until 1989.

During the eighties the gap between the three firms became very wide giving evidence of the superiority of EdF. The increase of TFP reached 2.6% per year against 0.9% for ENEL and -1% for RWE.

If we compare the fixed-base indices (TFP_B) with the Törnqvist indices, EdF and ENEL show lower levels of productivity, while RWE approximately confirms its previous levels. These findings are quite easily explained if we consider that in France and in Italy the best performances come from labour. This factor has been affected by higher price increases as compared to the other ones. Since the base-year is 1993 for Enel and 1989 for EdF, the TFP_B indices are biased upwards. The Törnqvist index, by weighting each different quantity index with its relative share at current prices also highlights that EdF and ENEL have been characterized by increasing performances in factors which have progressively become more expensive[8]. This is not the case of RWE, which maintained quite a homogeneous cost structure during the eighties.

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[7] The cost of production of the new reconverted plants has doubled.

[8] For the estimation of each factor's share at current prices, useful to weight every partial index and to build the Törnqvist index, we have decided not to use book-values for depreciation but we have inflated the amounts resulting from the application of the perpetual inventory method.

6.4 How could these results be interpreted?

The comparison between sales of electricity and productivity trends during the eighties underlines that one explanation of the different performances could relate to Kaldor-Verdoorn effects linked to the different rate of demand increase: 4.9% for EdF, 3% for ENEL and 0.4% for RWE. As far as inputs are concerned, the improvements of productivity contributed in particular by labour savings could reduce the importance of the different production technologies. A closer observation gives the possibility to see that Enel and EdF, which are both vertically integrated, have almost the same level of labour productivity. Many studies provide the evidence of higher productivity levels of vertically integrated electric power firms (Kaserman and Mayo, 1991) (Fraquelli and Ragazzi, 1995). The performance of the two firms seems to suggest that a wide integrated structure could offer more opportunities to achieve managerial economies by reorganizing the activity of workers in the different stages of the service. However, it must be noted that RWE too could enjoy some economies from the subsidiaries of the group operating in the coal industry. In fact vertical economies have also been found in backward integrated activities (Kerkvliet, 1991).

The trend of the home-country demand and the organisation structure of each firm could represent some good supports for the interpretation of the results but they are still insufficient in that they do not explain the low level of TFP for ENEL and the negative results of RWE. Regulation seems to play an important role. RWE's partial productivity indices give the evidence of the negative performance of capital and consumption. The drawbacks concerning the overinvestment of capital which could occur with rate of return regulation are evident in this case as the environmental investments do not justify such a high increase in capital assets. Turning to consumption, quality constraints about factors could be connected to the policy towards a massive use of German coal.

The constraints about the availability of factors are also evident in the case of Italy. Investments in new capacity have been characterized in time by high marginal costs because of the difficulties of finding new sites and the frequent interruptions during the construction of plants. At the same time the new law (1991) succeeded in increasing private production (Figure 2). This result has been obtained without competition, with an high increase of ENEL's costs of domestic supplies from private producers. Anyhow in the latest years the positive effects of social contracts devoted to improve productivity are supposed to be relevant but not sufficient to cover the costs of the environmental investments.

On the other hand EdF's long experience with programming contracts based on efficiency goals underlines the importance of social contracts in the form of a price-cap.

As our analysis is limited to three firms it is not possible to generalize but we can state that many of our findings are consistent with theoretical suggestions about the importance of regulation and the superiority of systems based on direct efficiency controls.

7. Concluding remarks

A competitive market could be the best solution for increasing productivity in the electricity industry. While we are moving towards that direction the quality of regulation can provide good results for integrated monopolies too.

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The empirical results coming from the comparison between EdF, ENEL and RWE seem to confirm the above statement putting the regulatory incentives or constraints among the variables able to explain the productivity performances.

Rate of return regulation and policies in favour of German coal have reduced managerial attention towards efficiency creating the conditions for negative RWE performances on capital and consumption. In Italy the constraints on new sites, the conversion of nuclear plants and the costs of domestic supplies of private producers have weakened the positive effects of demand increase. EdF's good performance has been generated by the increase of production but the attention to costs reduction by a programming contracts policy has certainly favoured the improvement process.

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Table 1 - Interventions Characterizing the Electric Power Industries

Year	France	Italy	Germany	Expected Effects
1970	Programming Contract			Increase in Production/Weak Increase in Efficiency
1984	I Planning Contract			Increase in Efficiency
1989	II Planning Contract			Increase in Efficiency/Reduction of Indebtedness
1982		Law 308/82		Slow Increase in Production by Independent Firms
1987		Referendum		Increase in Foreign Purchases/Decrease in Efficiency
1991		Laws 9/91 and 10/91		Strong Increase in Production by Independent Firms
1991		Programming Contract		Increase in Efficiency
1980			Contract with Coal Mines	Inefficient Management of Fuel Sources
1989			Unification with East Germany	Increase in Production
1990			Bto Reform	Increase in Efficiency

Table 2 - Primary Energy Sources

RWE			ENEL				EDF			
	1980	*1993*		*1971*	*1980*	*1993*		*1971*	*1980*	*1993*
Lignite	59%	51%	Hydroelectric Power	30%	24%	18%	Hydroelectric Power	39%	31%	14%
Coal	22%	22%	Thermo-electric Power*	63%	72%	80%	Thermo-electric Power**	55%	43%	3%
Other	10%	7%	Geo Thermo-electric Power	3%	2%	2%	Nuclear	6%	26%	83%
Nuclear	9%	20%	Nuclear	4%	2%	-				

* Mainly Oil
** Mainly Coal

Table 3 - Structure of Inputs at Constant Prices

Name	Year	Labour	Fuel Consumption	Depreciation	Cost of Capital	Purchases
ENEL	1971	0.50	0.14	0.19	0.14	0.03
	1980	0.40	0.20	0.24	0.11	0.05
	1993	0.27	0.18	0.34	0.08	0.13
EDF	1971	0.43	0.12	0.20	0.18	0.07
	1980	0.29	0.26	0.22	0.14	0.09
	1993	0.25	0.19	0.34	0.17	0.05
RWE	1980	0.24	0.34	0.13	0.06	0.23
	1993	0.21	0.38	0.17	0.06	0.18

Table 4 - Partial Productivities (Index Numbers)

Table 4a - Productivity of Labour

	ENEL		EdF		RWE
1971	100.0		100.0		
1972	112.3		109.8		
1973	123.9		117.8		
1974	123.2		121.9		
1975	117.1		124.4		
1976	124.5		136.6		
1977	129.7		142.7		
1978	138.6		154.4		
1979	147.1		162.6		
1980	151.7	100.0	169.3	100.0	100.0
1981	153.1	100.9	176.1	104.0	99.2
1982	159.7	105.3	169.7	100.3	100.3
1983	162.0	106.8	172.5	101.9	96.8
1984	171.2	112.9	187.0	110.5	100.2
1985	177.0	116.7	191.5	113.2	103.6
1986	182.5	120.3	203.0	120.0	97.3
1987	194.1	128.0	212.5	125.6	94.2
1988	205.5	135.4	218.8	129.3	95.3
1989	216.0	142.4	229.9	135.8	100.1
1990	226.1	149.0	238.9	141.2	101.9
1991	235.8	155.4	257.9	152.4	102.8
1992	246.7	132.6	265.7	157.0	101.4
1993	253.0	166.8	269.5	159.2	98.2

Table 4b - Productivity of Fuel Consumption + Purchases of Electricity

	ENEL		EdF		RWE
1971	100.0		100.0		
1972	101.5		113.6		
1973	94.1		117.2		
1974	91.9		70.3		
1975	92.9		66.5		
1976	89.4		59.8		
1977	95.9		73.3		
1978	94.0		75.1		
1979	88.2		69.6		
1980	85.5	100.0	60.7	100.0	100.0
1981	81.9	95.7	64.4	106.0	89.7
1982	86.3	100.9	64.6	106.4	87.3
1983	84.0	98.3	81.6	134.5	81.2
1984	82.2	96.1	88.1	145.1	79.2
1985	79.4	92.8	94.8	156.2	84.9
1986	82.9	96.9	100.1	164.8	80.9
1987	79.0	92.3	106.7	175.7	78.3
1988	76.3	89.2	116.7	192.3	76.9
1989	73.9	86.4	98.6	162.5	72.2
1990	73.8	86.3	103.6	170.6	77.1
1991	76.6	89.5	113.5	187.0	82.3
1992	76.2	89.1	130.8	215.4	88.1
1993	74.5	87.1	125.4	206.6	88.6

Table 4c - Productivity of Physical Capital + Financial Capital

	ENEL		EdF		RWE
1971	100.0		100.0		
1972	103.7		98.4		
1973	104.1		101.9		
1974	105.6		108.1		
1975	103.1		108.0		
1976	108.1		118.5		
1977	110.0		120.5		
1978	111.5		124.7		
1979	116.2		96.3		
1980	116.2	100.0	121.0	100.0	100.0
1981	116.0	99.9	112.1	92.6	100.4
1982	116.3	100.1	112.9	93.3	100.4
1983	112.6	96.9	107.4	88.7	93.1
1984	113.1	97.4	106.6	88.1	95.6
1985	110.3	94.9	101.8	84.1	94.1
1986	109.1	93.9	94.3	77.9	88.6
1987	112.6	96.9	111.6	92.2	81.5
1988	113.7	97.8	110.5	91.3	74.5
1989	115.0	99.0	127.4	105.3	73.7
1990	118.8	102.3	132.3	109.4	82.1
1991	117.4	101.1	120.2	99.3	80.5
1992	116.0	99.8	110.9	91.6	78.0
1993	111.0	95.5	119.2	98.5	73.8

Table 4d - Productivity of Physical Capital (Book-Value) + Financial Capital

	ENEL		EdF		RWE
1971	100.0		100.0		
1972	98.9		104.9		
1973	98.8		118.9		
1974	111.3		132.2		
1975	118.6		136.2		
1976	130.6		154.2		
1977	140.1		162.7		
1978	133.5		172.8		
1979	147.1		142.9		
1980	156.4	100.0	151.5	100.0	100.0
1981	165.9	106.1	152.8	100.9	119.6
1982	172.7	110.4	157.2	103.8	122.0
1983	145.8	93.2	158.5	104.7	113.5
1984	151.1	96.6	167.8	110.8	108.5
1985	123.2	78.7	168.1	111.0	117.9
1986	117.1	74.8	155.4	102.6	92.3
1987	109.0	69.7	153.1	101.1	90.6
1988	103.4	66.1	152.6	100.8	86.7
1989	112.5	71.9	170.6	112.6	91.3
1990	125.8	80.4	175.6	115.9	107.5
1991	121.8	77.9	164.4	108.6	109.1
1992	118.5	75.7	156.8	103.5	109.7
1993	122.8	78.5	164.2	108.4	100.2

Table 5 - Absolute Productivity Comparisons

		1971	1975	1980	1985	1990	1993
ENEL							
Sales of Electricity	(GWh)	81600	99000	134500	153300	189800	198400
Employees		105000	109700	115400	115200	112600	106600
Customers	(thousands)	17700	19900	22700	25100	26900	27800
Sales per Employee	(MWh)	777	902	1166	1331	1686	1861
Customers per Employee		169	181	197	218	239	261
EDF							
Sales of Electricity	(GWh)	120800	150300	219500	293100	364600	408000
Employees		94300	98400	107700	124700	121300	118300
Customers	(thousands)	19320	21480	23790	25560	27700	28300
Sales per Employee	(MWh)	1281	1527	2038	2350	3006	3449
Customers per Employee		205	218	221	205	228	239
RWE							
Sales of Electricity	(GWh)			114700	125900	122400	121500
Employees				22400	23700	23500	24200
Customers	(thousands)			3070	3184	3240	3280
Sales per Employee	(MWh)			5121	5312	5209	5021
Customers per Employee				137	134	138	136
FEDERAL REPUBLIC OF GERMANY (Vdew Reports)							
Sales of Electricity	(GWh)				328000	385000	366000
Employees					163000	165000	161000
Customers	(thousands)				30000	32000	33000
Sales per Employee	(MWh)				2012	2333	2273
Customers per Employee					184	194	205

Figure 1 - Total Factor Productivity (Index Numbers)

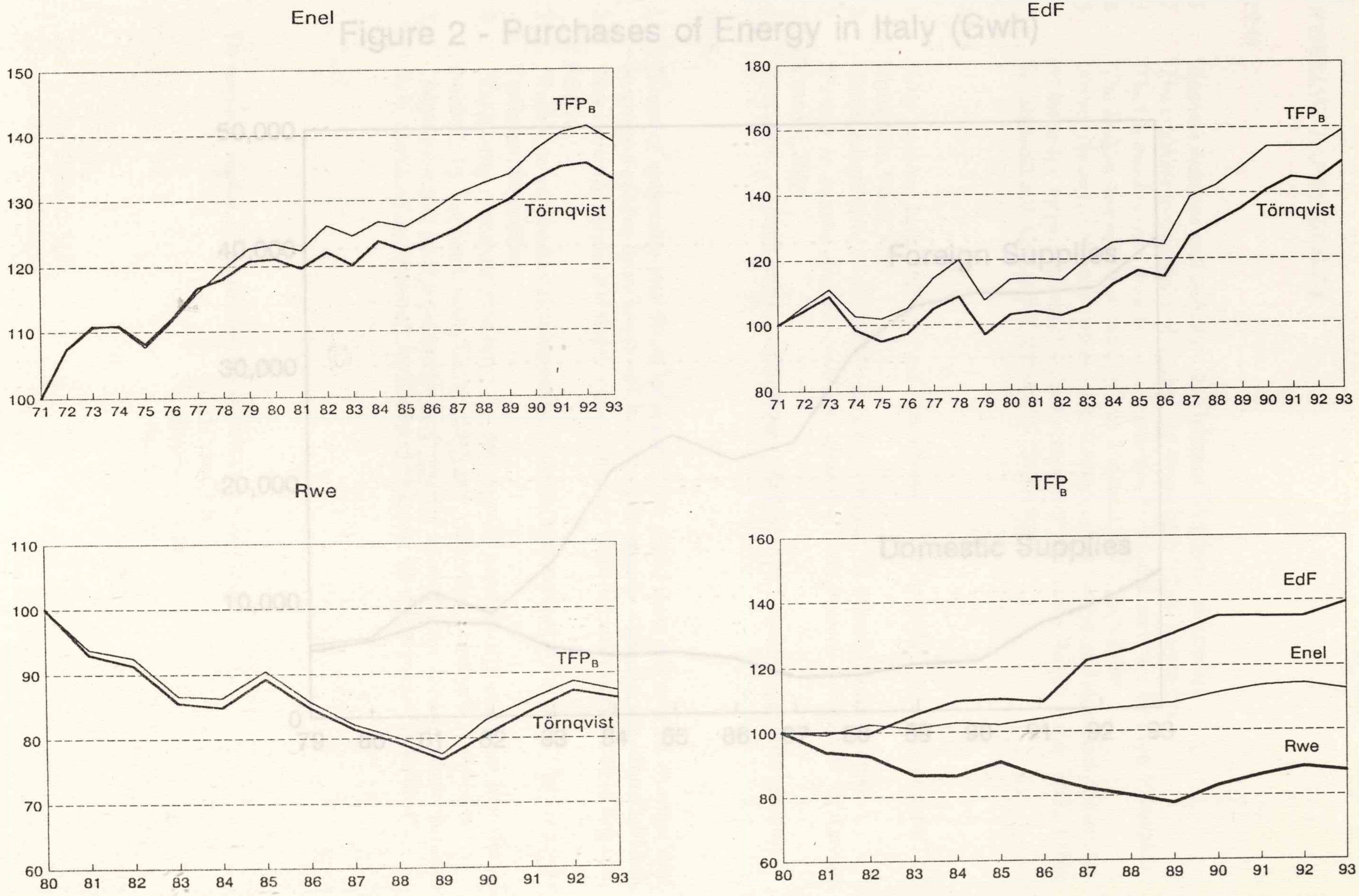

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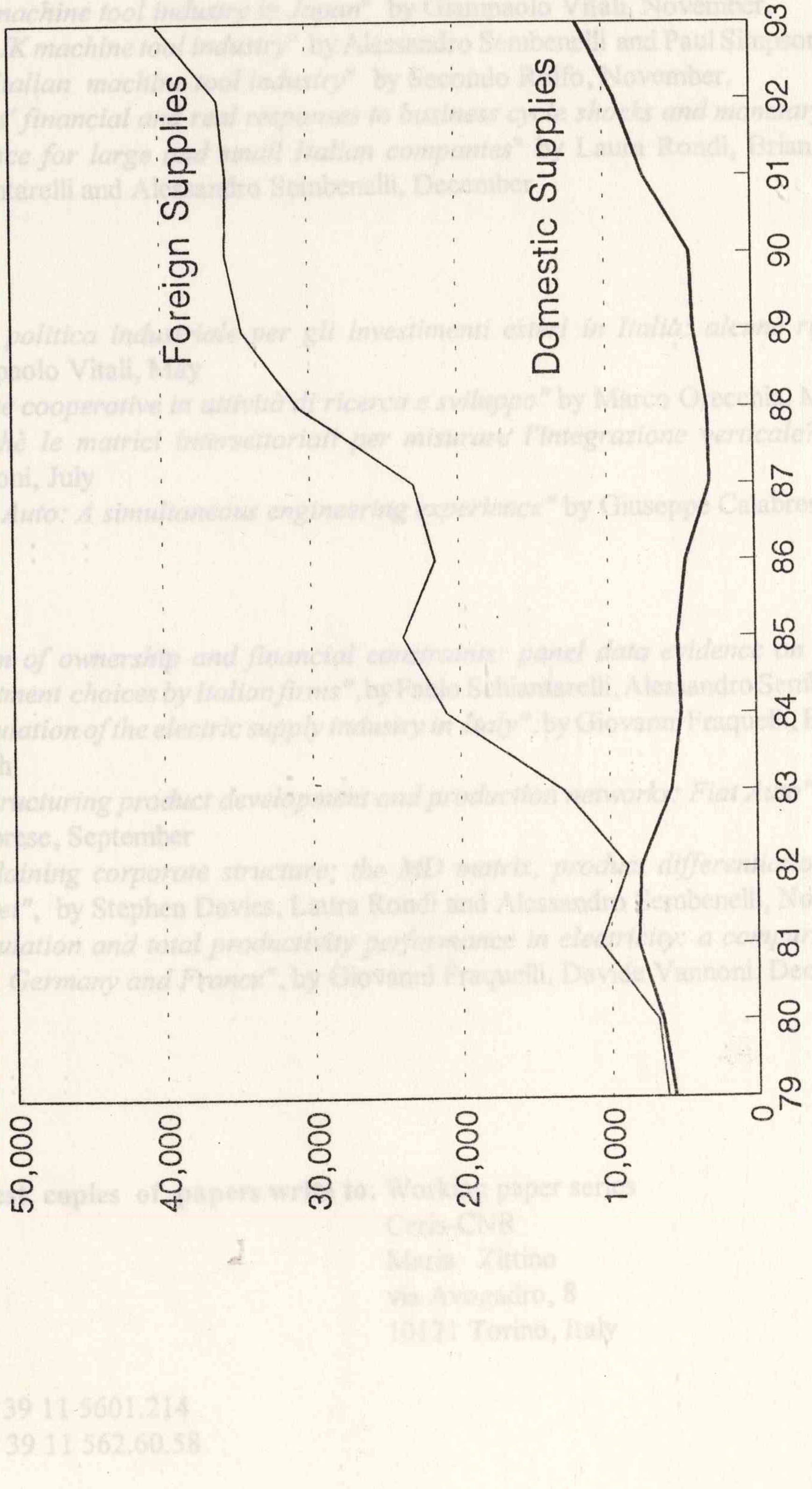
Figure 2 - Purchases of Energy in Italy (Gwh)



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